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REDUCED AGE AT FIRST CALVING: EFFECTS ON LIFETIME PRODUCTION, LONGEVITY, AND PROFITABILITY

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Summary

The primary advantages of reducing age at first calving (AFC) include reducing rearing costs as well as reducing time in which the heifer is only a capital drain on farm resources. The primary disadvantage of reducing AFC is that it is frequently associated with a reduction in first-lactation milk yield. Despite this reduction in first-lactation milk yield, production per year of herd life is typically increased by reduced AFC. Furthermore, although the first lactation yield may be influenced by AFC, future lactations are decidedly not. In addition, stayability and health of cows are not influenced by reduced AFC as long as heifers freshen at an adequate weight. Most analyses indicate that the financial advantage afforded from heifers that freshen at a low AFC seems to at the least offset any milk lost during the first lactation. Furthermore, when the time value of money is considered in this analysis, a reduced AFC (~22 months) seems likely to represent a more fiscally sound management decision. When applying these ideas on the farm, a properly managed feeding and breeding program should permit a first-lactation cow to weigh ~1,210 lb after freshening at 22 months of age. The National Research Council recommends a postpartum weight equal to 82% of her mature body weight. This can be achieved with a maximal prepubertal average daily gain (ADG) of 2 lb/day when a traditional preweaning program is employed or 1.8 lb/day when an intensified preweaning program is employed. Because of the well defined link between inadequate body weight at calving and increased mortality and morbidity in first-lactation cows, achieving this target post-calving body weight is of critical importance.

(Key Words: Heifers, Growth, Age at First Calving.)

Introduction

Between birth and first calving, replacement heifers are not generating income. Instead, this rearing period requires considerable capital expenditures, including feed, housing, and veterinary expenses. These expenses constitute 15 to 20% of the total expenses related to milk production. One approach to reducing this cost is to reduce the amount of time between the birth and first freshening of each heifer. The AFC has a profound influence on the total cost of raising dairy replacements in which older calving heifers are more expensive to raise than younger ones. Furthermore, reducing AFC also can improve the profitability of the enterprise by increasing lifetime milk production and milk production per year of herd life. The AFC can be reduced by a combination of increasing prepubertal ADG and decreasing age at breeding or by reducing age at breeding alone.

Universal recommendations for one particular AFC might be incorrect for all cattle on

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all farms, because the recommendation might not represent the management goals or capabilities of a particular production system or farm. This, however, does not mean that we should ignore AFC. Each dairy has its own set of unique management and environmental conditions that make a universal AFC and body weight after first calving a difficult goal to achieve. The purpose of this paper is to address the impact of reducing AFC on milk production, cow stayability, and farm profitability. Target growth also will be introduced and a basis for its use will be provided.

Milk Yield is Influenced by Age and Body Weight at First Calving and by Prepubertal Daily Gains

The biology involved with the interaction between reduced AFC and first-lactation milk yield is difficult to identify and quantify. This is because reducing AFC is often associated with increased prepubertal daily gain, reduced body weight at calving, or both, which have been shown to influence future milk yield.

Body weight at calving is positively correlated with first-lactation milk yield. A body weight of 1,210 lb is the approximate optimum post-calving weight to maximize first-lactation milk yield in U.S. Holsteins. Indeed, we reported no effects of AFC or prepubertal ADG on first-lactation milk yield when the variation in milk yield associated with post-calving BW was removed by covariate analysis.

The effect of increased prepubertal ADG on first-lactation milk yield in Holsteins is not as well defined. A wealth of data exists describing the negative effect that excessive prepubertal energy intake and increased ADG has on first-lactation milk yield in smaller-framed Danish breeds. The period during which excessive energy intake is thought to negatively influence first-lactation milk yield is between 3 months of age and puberty. It was proposed that average ADG in excess of 0.88, 1.32, and 1.54 lb for Jerseys, Danish Red, and Danish Friesians, respectively, would impair first-lactation milk yield. Using U.S. Holsteins, others observed a significant 5 to 13% reduction in first-lactation milk yield by prepubertal heifers growing at greater than 2.2 lb/day, compared with that of heifers grown at 1.69 to 1.56 lb/day. Contrary to the previous information, a third study reported no significant effect on first-lactation milk yield in U.S. Holsteins fed to gain either 2.18 or 1.72 lb/day. The AFC in that study averaged 24 months, without an effect of prepubertal ADG. These authors proposed that U.S. Holsteins might have a greater mature body weight than the Danish breeds, making them less sensitive to greater rates of gain. It is well documented that fat deposition in early-maturing breeds (i.e., smaller framed) is more responsive to plane of nutrition than larger, late-maturing breeds. Therefore, it is plausible that the smaller Danish breeds experience greater whole-body fat deposition than do United States Holsteins grown at a similar rate. This difference in conditioning at parturition is likely to have a negative influence on health and lactational performance in the smaller breeds.

The data on the effect reduced AFC has on first-lactation milk yield by U.S. Holsteins is variable. Some have observed no effect, whereas others have observed a negative effect. Milk yield in second and subsequent lactations has consistently been unaffected by reduced AFC. One study reported greater lifetime production and greater production per year of herd life in heifers that freshened at 23 vs. 26 months of age. Most of the studies suggest that reducing AFC from an average of 24.7 to 21.9 months resulted in an approximate 4.8% reduction in first-lactation milk yield (Table 1). In those studies, AFC was reduced by either reducing age at breeding alone, or in combination with increasing prepubertal ADG.

Effects of Age at First Calving on Health, Reproduction, and Stayability

In addition to milk yield, stayability of cows in a milking herd can have a profound impact on the profitability of the enterprise; therefore, potential effects of reducing AFC must be considered. Researchers from Brigham Young University addressed this issue by raising 443 U.S. Holsteins on an increased or restricted amount of energy from 6 weeks of age until breeding occurred at 748 lb (supporting 1.96 and 1.74 lb/day for the supplemented and restricted groups, respectively). As a result of the increased nutrient intake and younger age at first breeding, heifers receiving greater energy freshened at 22.4 months, compared with 24.6 months for those receiving a restricted amount of energy. Prebreeding ADG and AFC had no effect on milk yield in the first or subsequent six lactations. Calving difficulty was not different between the two AFC groups. Percentage of heifers in the herd at the start of the first, second, third, fourth, fifth, sixth, and seventh lactations averaged 100, 73, 46, 29, 18, 6, and 2%, respectively, with no difference between the two AFC groups. Likewise, after seven lactations, reasons for cows leaving the herd (including reproductive problems, mastitis, died, low production, reproduction, disease other than mastitis, or crippled) were not affected by prepubertal ADG or AFC.

More recently, researchers from the University of California-Davis evaluated the effects of altering age at breeding to change AFC. Holstein heifers (n = 1,933) on 3 commercial California dairy farms were raised similarly from birth through breeding, then retrospectively were assigned to one of three groups on the basis of AFC. All heifers presumably experienced the same pre- and postpubertal ADG. Differences in AFC were achieved by varying age at first conception. Average AFC for the three resulting groups was 22.3 (n = 514), 23.7 (n = 917), and 25.9 months (n = 474) for low, medium, and high AFC, respectively. Total milk yield in the first 310 days was 22,779; 23,461; and 23,665 lb for low, medium, and high AFC, respectively, with the high- and medium-AFC groups producing significantly more milk than the low-AFC group did.

Conception rate at first AI after freshening and number of inseminations per cow were 27.9% and 3.27, 36.9% and 2.85, and 30.8% and 3.23 for low, medium, and high AFC, respectively. Low- and high-AFC groups had poorer reproductive performance in both categories than did medium AFC. Number of days open for pregnant cows was unaffected by AFC and averaged 121 across the three groups. Furthermore, the fraction of cows pregnant at 310 days in milk averaged 80.6% and did not differ among groups. The percentage of cows having abortion averaged 10% and was not influenced by AFC. Difficulty associated with conception in early-calving heifers could be attributed to a greater energy demand for growth, resulting in less energy available for reproduction, when compared with that of presumably heavier heifers that freshened at an older age.

It has been well documented that calving difficulty has profound negative impacts on the health, reproduction, and stayability of first-lactation cows. Furthermore, heifer size at first calving, but not AFC, is correlated to incidence of dystocia. Supporting this data, the California researchers observed no effect of AFC on calving difficulty scores, indicating that their lowest mean body weight at calving (1,254 lb, low AFC group) was adequate to ensure ease of calf delivery. It should be noted in that study that body weight of pregnant heifers was estimated by using heart girth measurements. These authors also reported that, across all AFC treatments, cows requiring physical assistance with calving had greater mortality (4.9%) than those not having dystocia (2.7%). These facts illustrate the critical role that body weight at first calving has on the long-term health and stayability of cows.

In the California study, neither the incidence of health problems, culling, or mortality was influenced by AFC. Health problems (and average incidence among the three AFC groups) included retained placental membranes (3.3%), left displaced abomasum (2.9%), lameness (15.0%), and mastitis (19.4%). The AFC did not affect the incidence of these health problems. Likewise, AFC had no affect on the fraction of heifers culled after calving (17.6%) or on mortality (3.9%). There was, however, a tendency for the low-AFC heifers to die earlier in lactation than did the high-AFC cows (20.3 vs. 77.7 d). But the fraction of heifers that died or were sold before 310 DIM averaged 21.7% and was similar across all three AFC groups. In addition, survival analysis showed that the interval from calving to date leaving the herd averaged 255 d and was not affected by AFC.

A group from the University of Florida observed no effect of AFC on survival of first-lactation cows to begin a second lactation for 1,144 Florida Holstein heifers. Taken together, these studies strongly indicate that heifers freshening at ~22 months with adequate post-calving body weights have similar stayability in the herd as those freshening at older ages. The negative effect of freshening heifers under weight is quite profound and cannot be ignored.

Economics of Increased Prepubertal Daily Gains and Reduced Age at First Calving

The economics associated with reducing AFC has been the topic of much debate. Under the assumption that increased prepubertal ADG negatively influences first-lactation milk yield, a researcher from Ohio State University analyzed data from three studies to determine the economically optimal prepubertal ADG for U.S. Holsteins. To assess the financial impact of freshening heifers at a younger age, the net present value or time value of money ("a dollar five years from now is not worth the same as a dollar today") was considered. This assigns economic benefit to heifers generating income sooner by initiating lactation at a younger age. The economic optimum for prepubertal ADG and AFC was estimated to be between 1.98 and 2.42 lb/day and 22.4 and 20.6 months, respectively.

An economic analysis of the California study previously described found average AFC (and 310-d milk yield) for the three resulting groups to be 22.3 months (22,779 lb), 23.7 months (23,461 lb), and 25.9 months (23,665 lb) for low, medium, and high AFC, respectively. Rearing costs for the medium- and high-AFC groups were $40.34 and $107.89, respectively, more than that of the low-AFC group. Income for each AFC group was adjusted for the cost of rearing, estimated feed to increase milk yield, stillbirths, diseases, days open, culling, mortality, labor cost, and the value of milk and calf produced, as well as the value of a cow at the end of the 310-day study. Adjusted income was $119.73 and $9.08 more for the medium- and high-AFC cows, respectively, than for the low-AFC cows. These values were not significantly different, implying that no single AFC had an economic advantage over another. But these researchers did not consider the net present value of money in that analysis. If the net present value had been considered, it would presumably shift the economic advantage to the low-AFC heifers.

A Within-herd Analysis: Effects of AFC on Milk Production and Stayability

We recently evaluated the within-herd effect of AFC on lifetime milk production, stayability, and number of lifetime productive days. Lactation records from 2,519,232 first-lactation cows from 937 herds in California and the Northeast were analyzed by using the test-day model (TDM). The lactations occurred between January 1985 and December 2002. The TDM was employed for this analysis because it describes and accounts for factors that influence lactational performance such as calving year, season, management, and environment. Test-day residuals include the random genetic cow effects and treatment effects (AFC in this instance). These residuals are simultaneously adjusted for herd test day, days in milk, calendar month fresh, pregnancy, and management effects. Test-day analysis is considered to be a more appropriate approach to this type of data analysis because it assumes that global conditions are inappropriate for evaluating management (i.e., AFC) among different herds.

Average AFC for each year was calculated for each of the 973 herds. Within a herd, heifers were then retrospectively assigned to one of five treatments that fit around the herd mean AFC. The AFC treatments consisted of: 1) less than –63 days from the herd-by-year average AFC; 2) –22 to –63 days from the herd-by-year average AFC; 3) –21 to +21 days from the herd-by-year average AFC; 4) +22 to +63 days from the herd-by-year average AFC; and 5) greater than 63 days from the herd-by-year average AFC. Actual AFC across all herds for the five groups was 23.3, 24.3, 25.6, 27.2, and 30.3 months, respectively.

Once assigned to an AFC group, cows were assigned to one or more opportunity groups defined as 3, 4, 5, 6, 7, or 8 years of age. Heifers were assigned to opportunity groups if they had the opportunity to be the age of the group. For example, a cow that has had the opportunity to be 5 years old at the time of test would be assigned to the 3, 4 and 5 year opportunity groups, but not to the 6, 7, or 8 year group. The sum of her 5-year total milk production and the sum of her 5-year total productive days (defined as the number of days lactating) would be averaged with all other cows in the 5-year opportunity group. Likewise, the sum of her 4-year total production and the sum of her 4-year total milk production would be averaged with all other cows in the 4-year opportunity group, and so forth. By the definition of an opportunity group, her data would be included in the 5-year opportunity group even if she had died at 4 years of age. Use of opportunity groups in this analysis permitted the evaluation of total milk produced and total productive days at a given age across treatments (i.e., AFC) while simultaneously discounting the treatments for any treatment-associated differences in early-death loss.

The total number of cows in each of the five AFC treatments and the number assigned to their appropriate opportunity groups is in Table 1. These treatments will be referred to by their average AFC from this point on. The differences in AFC within farm and year are assumed to have arisen from a combination of differences in prepubertal ADG and age at first breeding or from differences in age at first breeding alone.

Perhaps the most obvious benefit of reducing AFC is its effect on the number of productive days in a cow's lifetime. Total productive days of cows in each AFC treatment are in Table 2. Heifers freshened at a younger age enter the productive phase of their life sooner. Heifers with a younger AFC have an advantage over those freshening at an older age throughout all six opportunity groups. Within a given AFC treatment, number of productive days increases rapidly in the first three opportunity groups, and then its rate of increase slows as cows approach the 8-year opportunity group. This occurs because moving from the 7- to the 8-year opportunity group, for example, likely only adds a few cows that have actually survived this long. Their number of productive days (presumably quite high) is averaged with all other cows in that AFC group, which is likely heavily weighted with cows that died at a younger age and, therefore, had fewer productive days. This causes the increase in number of productive days to slow in the older opportunity groups. This can be observed happening across all five AFC treatments.

Effect of AFC on number of productive days for the five AFC treatment groups is more clearly illustrated in Figure 1, in which the data are represented as a difference from the 25.6-month-AFC treatment. Again, it is apparent that heifers in the 23.3-month-AFC treatment have the obvious advantage over all other AFC groups. This is despite the average number of productive days decreasing from a high of 59 days more than the 25.6-month AFC group in the 3-year opportunity group to approximately 35 days in the 5- through the 8-year opportunity groups.

The most effective way to evaluate the benefit of reducing AFC and increasing the number of productive days in a cow's lifetime is to consider her lifetime milk production. Lifetime milk production for each of the five AFC treatment groups in the six opportunity groups is given in Table 3. For heifers in the 3-year opportunity group, those that freshened at 23.3 months produced nearly twice the amount of milk as those that freshened at 30.3 months. This trend for increased lifetime milk production continues even to the 8-year opportunity group. As was observed with the total number of productive days, within a given AFC treatment group, the total milk production in each opportunity group increases rapidly from the three- through 5-year opportunity groups, then slows as cows progress through to the 8-year opportunity group. This occurs for the same reason total number of productive days increases at a rapid, then slower, rate.

The differences across the five AFC treatment groups in lifetime milk yield are more visually apparent in Figure 2. Lifetime milk production in this figure is presented as the difference from the 25.6 AFC group, which represents the herds' average AFC. Heifers calving in the 23.3-month-AFC group produced more milk in their lifetime than all other AFC groups through the 5-year opportunity group, with the greatest difference at the 3- and 4-year opportunity groups. In the 3-year opportunity group, few heifers in the 30.3-month-AFC group have freshened, and those that have freshened are likely only in the early stages of their first lactation. Even though the increase in milk yield for the 23.3- and 24.3-month-AFC treatments becomes similar by 6 years, the production and economic advantage lies with the 23.3-AFC group, because they produce more milk sooner. This allows the producer to capitalize on the time value of money discussed previously. In agreement with other data, this increase in lifetime milk production clearly illustrates the advantage of freshening at a younger age.

At first glance, average stayability (percentage survival) for the five AFC treatments (Table 4) seems to weigh heavily against calving at earlier AFC. Other researchers have reported that stayability is not influenced by AFC. Although our data may seem to lead to a different conclusion, it is important to understand that we have calculated stayability by using a different time reference than others have used. They calculated stayability after the conclusion of the first lactations. Therefore, heifers from both high- and low-AFC groups were "exposed" to the same length of lactation, and all had an equal amount of production data upon which culling decisions were made. In our assessment, we compared stayability at a common age; so, for example, in the 3-year opportunity group, heifers in the 23.3-AFC treatments were milking an average of 355 days, whereas those in the 30.3-AFC treatment were milking an average of 166 days (Table 2). Therefore, younger calving heifers have more than twice the amount of production data from which culling decisions could be made and they have a decidedly greater opportunity to be culled. Perhaps most important to note is that the differences in stayability between heifers in the 23.3-, 24.3-, and 25.6-AFC treatments are quite similar, even at the lowest age opportunity groups. The differences between how we compare stayability across AFC treatments and how others made their estimates is important to understand.

Summary of Within-herd Analysis of AFC

Taken together, these data support management decisions that result in working toward a lower AFC. The increase in lifetime milk production that results from calving at 23.3 months, compared with 25.6, 27.2, or 30.3 months, is substantial and difficult to ignore. Although the lowest average AFC was 23.3 months, it seems safe to conclude that further increases in number of productive days and lifetime milk production would occur when average AFC was further reduced to 22 months. This conclusion is based upon the stayability data and the lifetime-production data from other studies.

A Systematic Approach to Managing Heifers: Target Growth

The target-growth system was first modified for dairy heifers, and further modified and adapted by the National Research Council, to establish a systematic approach to heifer management. The objective of a farm manager should be to determine at what age-weight relationship cattle generate the greatest marginal profit and then manage to that target. Results presented herein indicate that the optimal age and body weight at first calving is around 22 months and 1,210 lbs, but variability in mature body size was not considered in these suggestions. The biologically and economically ideal body weight and age at calving is expected to differ with differing body weight at maturity. Therefore, knowing a herd's mature body weight is required for successful application of this system. At its core, the target-growth program is a straightforward approach to determining, managing, and attaining these age and body-weight targets.

The National Research Council recommended that body weight at first conception and after first calving should be 55% and 82% of mature body weight, respectively. If the mature body weight of the typical high-merit U.S. Holstein is assumed to be 1,474 lb, this would set the target body weight at first conception and after calving at 807 and 1,210 lb, respectively. Naturally, an earlier target AFC requires greater rates of gain to achieve target weights at conception and after calving. With an efficient breeding program, however, AFC can be effectively reduced without requiring excessive prepubertal ADG. An additional approach to control rates of gain between 3 months of age and puberty is to feed for increased preweaning rates when body growth is most efficient.

The third set of targets consists of preweaning ADG and weaning age. Two examples of target-growth solutions are shown in Figures 3 and 4. Both examples illustrate the target weights, ages, and rates of gain for heifers freshening at 22 months and weighing 1,210 lb after calving. All assumptions are similar between the two examples, with the exception of the preweaning program. Figure 3 assumes that a traditional preweaning program is employed that supports an ADG of 1.0 lb/day during the milk-fed phase. Figure 4 assumes an intensified preweaning program that supports a preweaning ADG of 2 lb/day.

Use of an intensified preweaning program yields approximately 56 lb of additional growth after 8 weeks on milk, relative to a traditional calf program. This advantage in body weight at weaning permits less ADG from weaning to conception (2.0 vs. 1.8 lb/day) while still meeting the target age and body weight at conception. This particular intensified preweaning program is, however, more costly than a traditional program simply because more milk (or milk replacer) is required to achieve the additional weight gain. If a high quality all-milk milk replacer is used, a heifer on this intensified program would require approximately 57 lb more powder to achieve the additional 56 lb of body weight at weaning. Starter also would be consumed starting by approximately 3 weeks of age to support this additional body weight at weaning.

Table 1. Recent Publications Evaluating the Effect of Reduced Age at First Calving (AFC) on First-Lactation Milk Yield

	Prepubertal ADG, lb/day		Weight after calving, lb		AFC, months		First-lactation milk yield, lb		
Study	Late AFC	Early AFC	Late AFC	Early AFC	Late AFC	Early AFC	Late AFC	Early AFC	Milk yield, % change
1	1.63[1]	1.63[1]	1,107	997	26.1	22.9	9,797[2]	9,189	–6.2
2	NR[3]	NR	NR	NR	24.6	22.2	15,367	14,804	–3.7
3	NR	NR	1,276	1,212	23.6	20.6	18,240	16,548	–9.3
3	NR	NR	1,324	1,291	25.6	22.7	17,789	17,310	–2.5
4	1.50	1.84	1,115	1,197	23.0	21.9	20,176[x]	21,173[y]	+4.9
5	1.50	2.07	1,210	1,144	24.5	21.3	21,721[a]	20,651[b]	–4.9
6	1.69	2.46	1,186	1,133	23.6	20.7	18,962[a]	16,507[b]	–12.9
7	1.69	2.49	NR	NR	25.4	22.4	15,745[a]	14,969[b]	–4.9
8	1.65[2]	1.65[2]	1,327	1,256	25.9	22.3	23,665[a]	22,779[b]	–3.7
Mean	-	-	-	-	24.7	21.9	-	-	–4.8

[1]Prepubertal ADG not reported. Rate was calculated on the basis of data included in the paper.
[2]First-lactation milk yields were reported to be similar when AFC was used as a covariate.
[3]Not reported.
[a,b]Means within study having different superscript letters differ (P<0.05).
[x,y]Means within study having different superscript letters differ (P<0.10).

Table 2. Numbers of Cows Used in the Analysis of Five Age-at-First-Calving (AFC) Treatments and Six Age Opportunity Groups

	AFC treatments, months				
Age	23.3	24.3	25.6	27.2	30.3
– years –	No. of cows				
3	251,399	737,311	824,970	360,487	345,065
4	221,654	638,167	715,156	314,981	305,576
5	193,777	550,140	610,959	272,799	266,159
6	165,115	461,744	515,814	232,651	228,212
7	138,243	383,724	426,985	193,439	191,674
8	110,552	304,365	347,693	159,481	158,338

Table 3. **Average Number of Productive Days for Five Age-at-First-Calving Treatments and Six Age Opportunity Groups**

	AFC treatments, months				
Age	23.3	24.3	25.6	27.2	30.3
– years –	------------------------------ Productive days ------------------------------				
3	354.8	328.5	296.0	252.4	165.7
4	614.2	593.8	565.7	527.6	450.5
5	796.9	781.0	756.5	723.9	652.4
6	915.9	902.6	880.7	850.6	781.9
7	990.8	975.6	956.1	929.3	861.2
8	1,035.0	1,017.8	998.0	973.1	906.5

Table 4. **Average Total Milk Production across Five Age-at-First-Calving (AFC) Treatments and Six Age Opportunity Groups**

	AFC treatments, months				
Age	23.3	24.3	25.6	27.2	30.3
– years –	------------------ Average total milk production, lb ------------------				
3	19,758	18,484	17,345	15,803	10,941
4	34,659	33,609	32,318	30,540	26,224
5	45,445	44,568	43,243	41,503	37,554
6	52,483	51,746	50,490	48,809	45,054
7	56,874	56,005	54,846	53,330	49,632
8	59,424	58,450	57,255	55,858	52,239

Table 5. Average Stayability (Percentage Survival) Across Five Age-at-First-Calving (AFC) Treatments and Six Age Opportunity Groups

	AFC treatment, months				
Age	23.3	24.3	25.6	27.2	30.3
– years –	------------------------------ Survival, % ------------------------------				
3	80.2	81.5	82.6	85.5	90.1
4	56.6	61.0	62.3	64.6	66.8
5	39.9	40.9	41.9	43.4	44.2
6	25.5	25.0	25.7	26.6	27.1
7	13.9	14.1	14.6	15.3	15.4
8	7.4	7.4	7.7	8.2	8.2

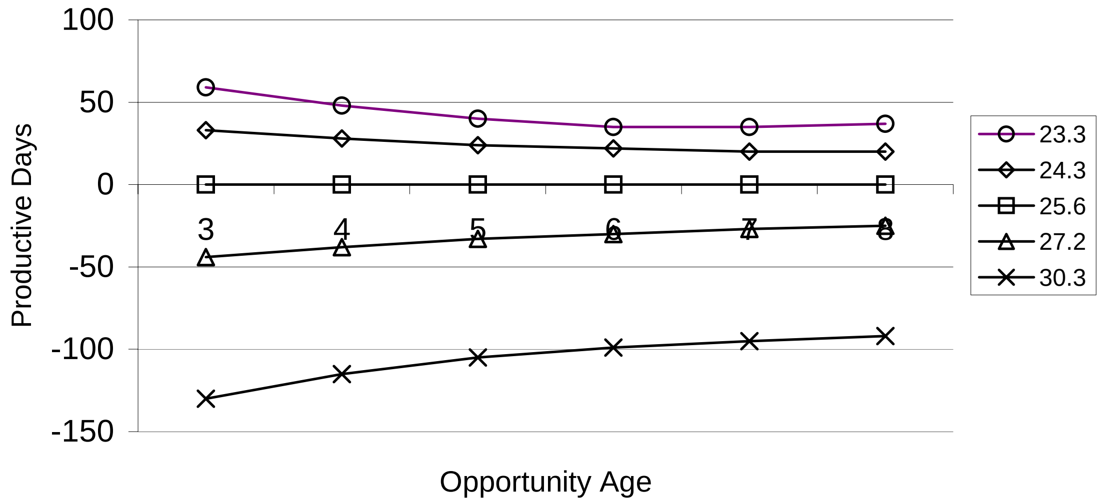

Figure 1. **Average Number of Productive Days for Five Age-at-First-Calving (AFC) Treatments and Six Age Opportunity Groups (Difference from mean 25.6-month-AFC treatment).**

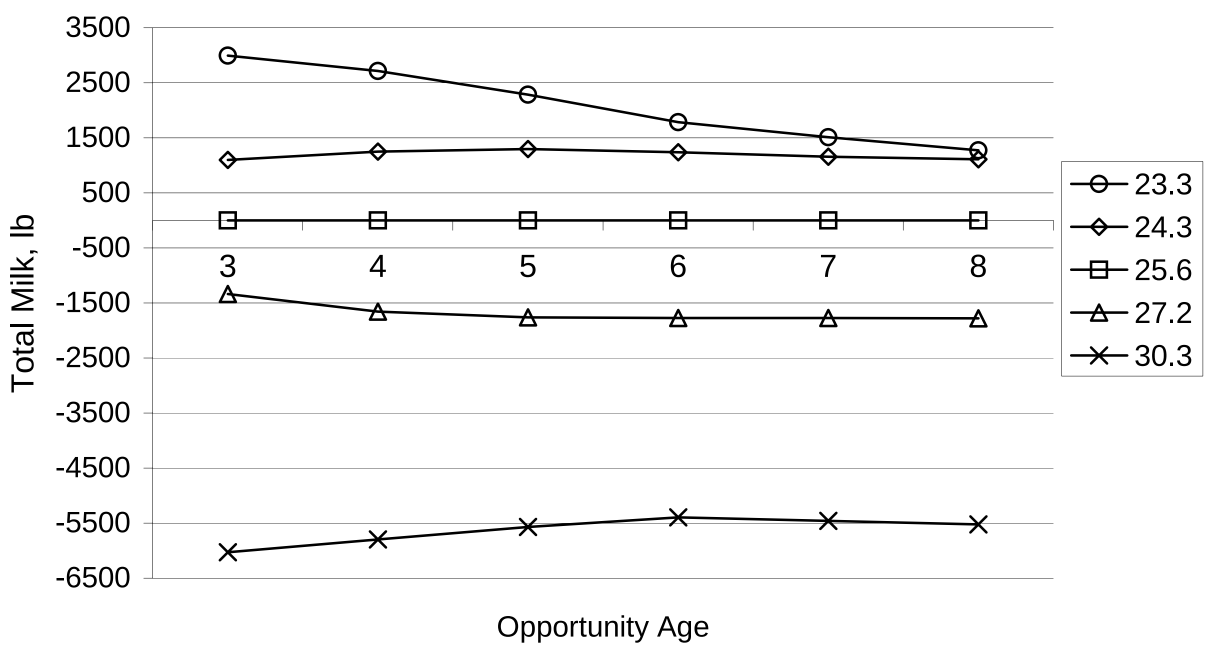

Figure 2. **Average Total Milk Production for Five Age-at-First-Calving (AFC) Treatments and Six Age Opportunity Groups (Difference from mean 25.6-month-AFC treatment).**

Inputs		Assumptions	
Age first calving, mo	22	Birth wt, lb	90
Preweaning ADG, lb/day	1.00	Conceptus wt at birth, lb	132
Weaning age, weeks	8	Conceptus growth in last 1/3 of gest., %	65%
Mature BW, lb	1474	Gestation length, days	279
BW at conception, % MBW	55%	BW at puberty, lb	620
BW after 1st calf, % MBW	82%		

	Birth	Weaning	Puberty	Conception	Pre-Calving	Post-Calving
BW, lb	90	146	620	811	1341	1209
Age, weeks	0	8	38	56	96	96
Age, days	0	56	268	392	671	671
Age, months	0	0.3	8.8	12.9	22	22
BW, % mature, BW	6%	10%	42%	55%	91%	82%

ADG SOLUTIONS:

Required Rates of Gain	lb/day	
Weaning to conception	1.98	
Conception to pre-calving	1.90	(includes conceptus growth)
Conception to pre-calving	1.43	(does NOT include conceptus growth)

Figure 3. Required Rates of Gain from Birth to Freshening to Meet Target Body Weight and Age at Conception and First Calving When a Standard Preweaning Program is Employed.

Inputs		Assumptions	
Age first calving, mo	22	Birth wt, lb	90
Preweaning ADG, lb/day	2.00	Conceptus wt at birth, lb	132
Weaning age, weeks	8	Conceptus growth in last 1/3 of gest., %	65%
Mature BW, lb	1474	Gestation length, days	279
BW at conception, % MBW	55%	BW at puberty, lb	620
BW after 1st calf, % MBW	82%		

	Birth	Weaning	Puberty	Conception	Pre-Calving	Post-Calving
BW, lb	90	202	620	811	1341	1209
Age, weeks	0	8	42	56	96	96
Age, days	0	56	293	392	671	671
Age, months	0	0.3	9.6	12.9	22	22
BW, % mature BW	6%	14%	42%	55%	91%	82%

ADG SOLUTIONS:

Required Rates of Gain	lb/day	
Weaning to conception	1.81	
Conception to pre-calving	1.90	(includes conceptus growth)
Conception to pre-calving	1.43	(does NOT include conceptus growth)

Figure 4. Required Rates of Gain from Birth to Freshening to Meet Target Body Weight and Age at Conception and First Calving When an Intensified Preweaning Program is Employed.